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WETTABILITY ANALYSIS ON COPPER SUBSTRATE BY EMERY ABRASION AND COPPER NANO COATING

T. NITHYANANDAM & K. PALANISAMY

Department of Mechanical Engineering, M. Kumarasamy College of Engineering, Karur, Tamil Nadu, India

ABSTRACT

In recent years, the heat removal from the thermal system plays a major role in all heat generating equipments. It is very important in electronic products, nuclear reactor etc. Effective heat removal is done by different surface modification techniques. It is reported that the surface modification was done by making abrasion on the surface by different grades of emery sheets and nano coating on the copper surface. Wettability is the important parameter in multiphase heat transfer. Wettability was determined by water contact angle on the bare and modified surfaces. In this work, copper surfaces were abraded with three different grades of 100, 220 and 600 emery sand papers. Also copper nano coating was made on the surface with three different coating duration of 15, 30 and 45 minutes. In this investigation wettability was improved on nano coated surfaces and also surfaces exhibited hydrophilic nature.

KEYWORDS: Heat Removal, Modified Surface & Nano Coating

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Original Article

INTRODUCTION

In the present-day, the most important thing in electronic equipment is the removal of heat from their system. Usually, these heat dissipation processes are done using small equipments like cooling fans but which won't remove the heat from the equipment rapidly and separate power system is needed to drive them. Mostly proactive techniques were used, but the main role is done by the inactive techniques in the case of heat management systems. Wettability is the most important factor in the case of boiling heat transfer. The boiling properties of any surface can be altered by changing the wettability of the surface which is usually determined using the contact angle of the surface. [1] The drenching and wicking properties are studied on nano coated surface by determining the contact angle of those surfaces. The common connection between contact angle and heat transfer was being exposed. [2] The driving power of the liquid was regulated by the surface that is coated in nano scale. The change in contact angle is clearly exposed by coating in nano scale. [3] The author recommended that the wettability is improved by the coating of nano particles on surface which also increases the rate of heat transfer in saturated pool boiling. [4] Surface alteration manipulated the wettability and surface energy of the surface and the level of surface deposition were also differed. [5] Contact angle drop off from 80^o to 20^o, the critical heat flux improvement was reached momentously. [6] The coated nano material enhanced the wettability of the surface and the main cause for the enhancement of critical heat flux. The decrease in surface tension decreased the critical heat flux. [7] The coating of nano materials in boiling of nanofluid increased the surface wettability which improved the rate of heat transfer. [8] The rise in critical heat flux was assisted by wettability improvement by nanostructure on the boiling surfaces. [9] The noteworthy reduction in contact angle of RGO film coated surface improves the cohesive property

of cooling liquid with surface increases the heat transfer coefficient and critical heat flux. [10] CNT coated copper surface showed poor wettability than the bare copper surface also this hydrophilic nature of the surface improved the critical heat flux in pool boiling of water at atmospheric pressure. In these findings, the wettability of nano coated copper surface has been stated and DC sputtering method was deposited with numerous time durations. [11-12] MWCNT/ water based nano fluid shows enhanced heat transfer in helically coiled tube solar collector.

EXPERIMENTAL SETUP

In this current work, ten pure copper substrates (Cu - 99.9%) were inspected. Four substrates were without any coating abraded with different grade of emery paper, three substrates were deposited by copper nano particles and remaining three substrates were deposited by titanium oxide nano particles. Three copper substrates were taken and they were abraded with three different types of emery papers like 100, 220 & 600 respectively. After the abrasion of the surface the copper substrates were cleaned completely with acetone solution to remove the small scrap particle created during the process of abrasion. Four substrates, one normal surface and there other abraded surface were tested for wettability with goniometer. DC magnetron sputtering method was selected for nano coating, because the bonding between substrate and coated materials shows good strength and high mechanical durability. In sputtering process, a permanent magnet structure was positioned after the target aiding as a deposition source. Plasma restrained on the target was attained by placing a permanent magnet structure behind the target surface. The resulting magnetic field formed a closed-loop annular path acting as an electron trap that redirects the path of the secondary electrons expelled from the target into a cycloidal path, greatly escalating the likelihood of ionization of the sputtering gas within the confinement zone. In DC sputtering method depositing time was chosen as main parameter. Deposition was done on different time scale as 15 minutes, 30 minutes and 45 minutes. In DC sputtering Unit, vacuum was provided by rotary pump and diffusion pump. In rotary pump most of the vacuum was produced and 10^{-6} mbar vacuum is sustained during the sputtering process. The copper substrate of 10mm x10mm is fixed on the glass plate of 25 mm width and 75 mm length. The copper and titanium oxide target was machined for 50 mm diameter and 7 mm thickness. The inert gas argon was engaged for sputtering, because non reacting gas with target material. Due to high molecular weight of the argon gas it created high sputtering and higher coating rate. The gas inlet pressure was sustained as 0.5 kg/cm^2. The DC magnetron power supply 0.3 kVDC was picked and the equivalent magnetic coil current was 0.6 Amps DC. Positively charged argon ions from the plasma were speeded up the negatively biased target (cathode), resulting in material being sputtered from the target surface. Primarily coating was done on copper for copper nano particles for three different time scale as declared. Then copper surface was deposited by titanium oxide nano particles for equivalent time scale. In this study the sessile drop method was used to calculate the contact angle of water. The quantity of water dropped on the substrate was 3 µl. So every time equivalent quantity of water was dropped and average contact angle was determined

RESULTS AND DISCUSSIONS

The surface properties were examined and also wettability analysis was conducted before and after every coating on the substrate. The surface of copper material is abraded by emery paper in uni-direction. The direction of abrasion of the emery paper will also accounts for the surface roughness and wettability of the surface. The change in direction of pattern of abrasion changes the surface roughness in different levels. The wettability was investigated by measuring the contact angle of water by the readings of goniometer. The coating results from the Figure 1 to 4 for different emery grade displays that the contact angle of water over copper surface and Figure 5 shows continuous increase in wettability with increase in

surface roughness. On seeing the images and results from goniometer for the determination of contact angle it is clear that the increase in surface roughness increases the wettability of the surface. In the surface morphology analysis, the copper nano particles were deposited homogenously over the surface and roughness of the whole surface was even from the microstructure of the substrate from Figure 8 to Figure 10.

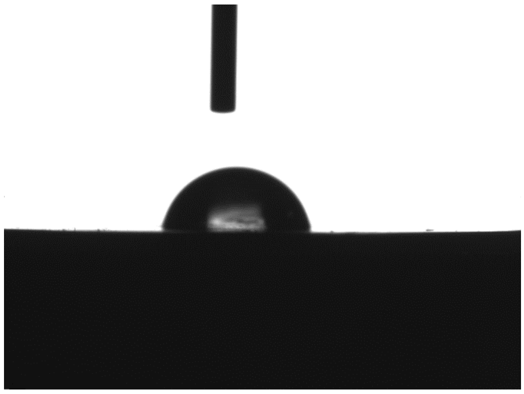

Figure 1: Bare Copper Surface

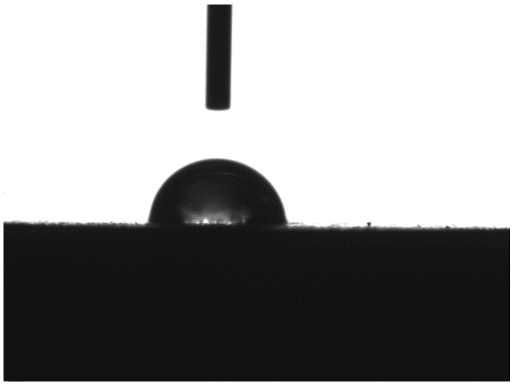

Figure 2: Copper Surface Abraded with Emery Grade 100

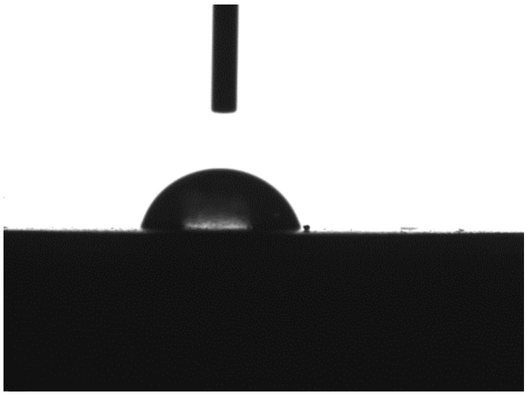

Figure 3: Copper Surface Abraded with Emery Grade 220

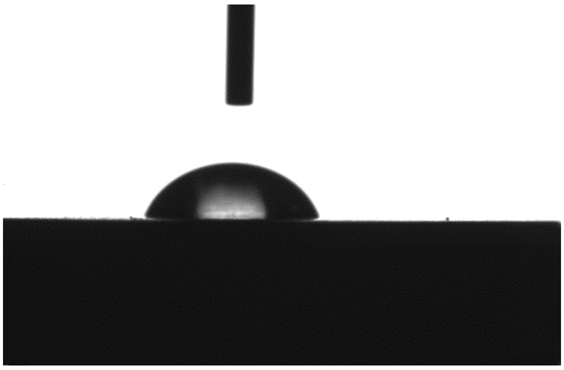

Figure 4: Copper Surface Abraded with Emery Grade 600

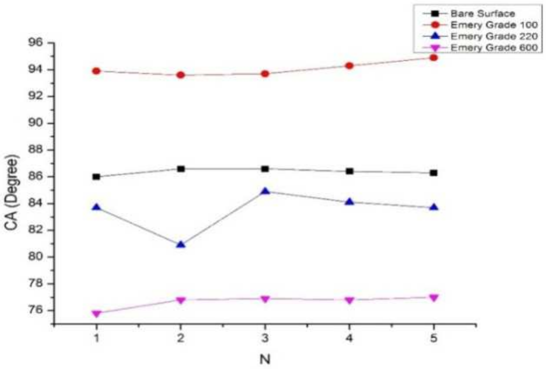

Figure 5: Copper Surface without Coating CA Analysis

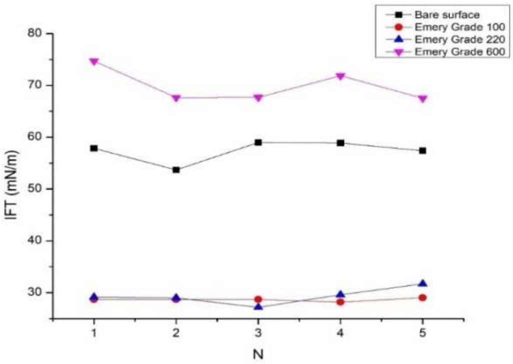

Figure 6: Copper Surface Without Coating IFT Analysis

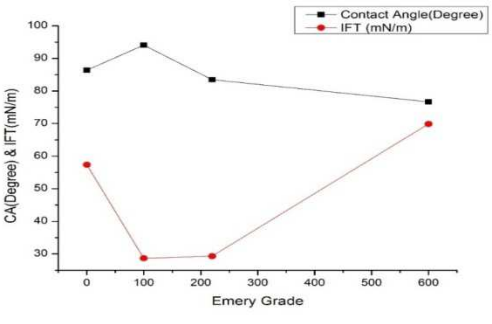

Figure 7: Copper Surface without Coating Comparison of CA & IFT

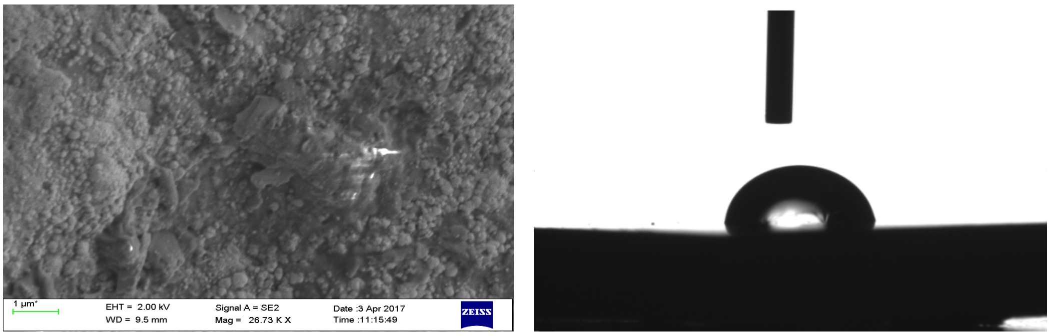

Figure 8: Copper Nano Particles 15 Minutes Coating Duration

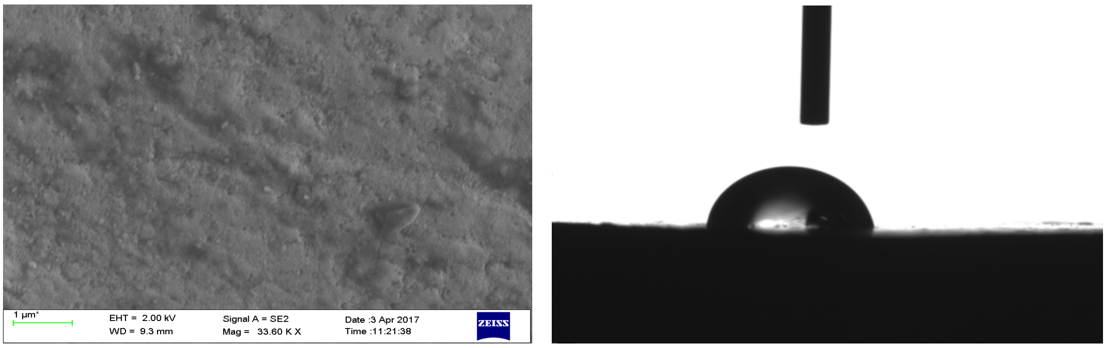

Figure 9: Copper Nano Particles 30 Minutes Coating Duration

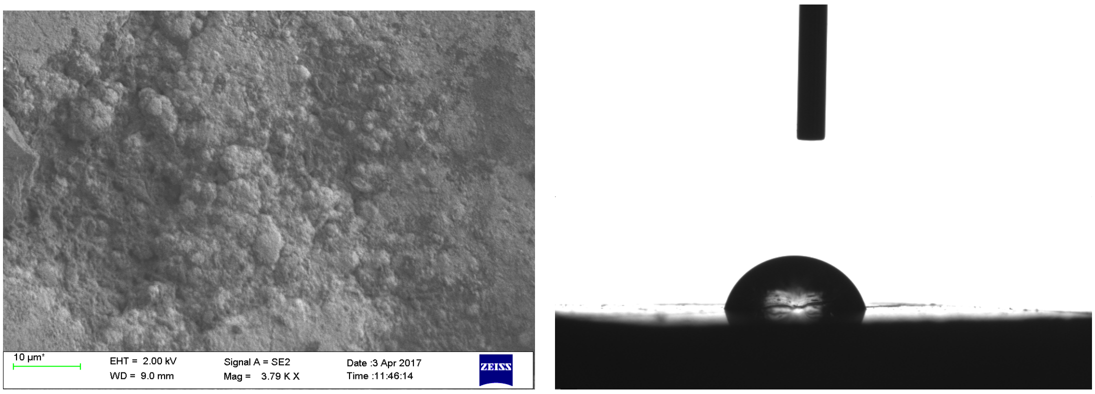

Figure 10: Copper Nano Particles 45 Minutes Coating Duration

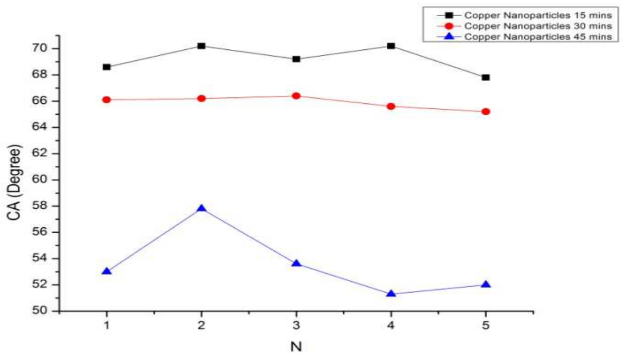

Figure 11: Copper Nanocoating CA Analysis

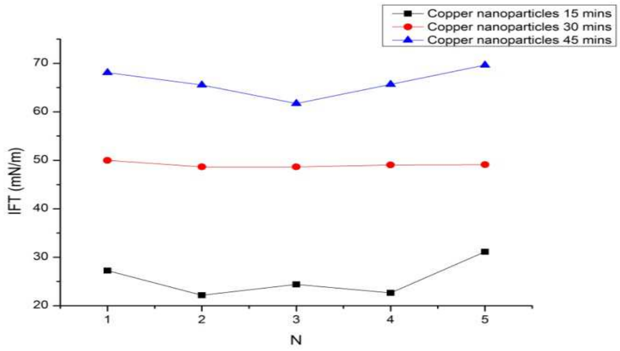

Figure 12: Copper Nanocoating IFT Analysis

The coating results from the Figure 11 display that the contact angle of water over a copper surface with copper surface with copper nano particles declines significantly and yields good wettability with rise in coating time. The thickness of coating has been enhanced. Figure 8 to Figure 10 visibly show the contact angle declines and wettability improved, surface attainment to superhydrophilic nature. This superhydrophic nature of the surface will enhance the boiling heat transfer and critical heat flux in pool boiling of water.

CONCLUSIONS

- The emery abraded copper surfaces at fine emery grade showed good wettability than the course emery abraded surface.
- The copper nano coated surfaces exhibit good wettability and wettability increases with coating time.
- The super hydrophilic nature of the surface will lead to enhance heat transfer in many applications.

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